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# ULTRA-LOW FREQUENCY

# BAND-PASS FILTER

## OPERATING AND MAINTENANCE MANUAL

**Models 330-A, 330-AR**

**Models 330-M, 330-MR**

**SERIAL NO.** 1558

**MODEL NO.** 330-M

**KROHN-HITE CORPORATION**

**580 Massachusetts Ave., Cambridge 39, Mass., U.S.A.**

## SERVICE AND WARRANTY

KROHN-HITE Instruments are designed and manufactured in accordance with sound engineering practices, and should give long trouble-free service under normal operating conditions. If your Band-Pass Filter fails to provide satisfactory service and you are unable to locate the source of trouble, write to our Service Department giving all the information available concerning the failure.

Do not return the instrument without our written authorization, for in most cases we will be able to supply you with the information necessary to repair the Band-Pass Filter and thus avoid the transportation problems and costs. When it becomes necessary to return the instrument to our factory, kindly pack it carefully and ship it to us via express, prepaid.

KROHN-HITE Instruments are conservatively designed to provide continuous reliable service under normal laboratory conditions. The material and workmanship in every new instrument manufactured by Krohn-Hite is guaranteed for one year from the date of shipment to the original purchaser. Any instrument developing defects during this period will be repaired or replaced without charge when the failure is the result of defective material or workmanship. This warranty does not apply to electron tubes, fuses, batteries, transistors, and other semiconductor devices.

KROHN-HITE CORPORATION reserves the right to make design changes at any time without incurring any obligation to incorporate these changes in instruments previously purchased.

BAC 176 136A

ULTRA-LOW FREQUENCY

# BAND-PASS FILTER

## INSTRUCTIONS

for

**Models 330-A, 330-AR**

**Models 330-M, 330-MR**

**KROHN-HITE CORPORATION**

**580 Massachusetts Ave., Cambridge 39, Mass., U.S.A.**

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Models 330-A
◀ and 330-M

Models 330-AR
and 330-MR ▶

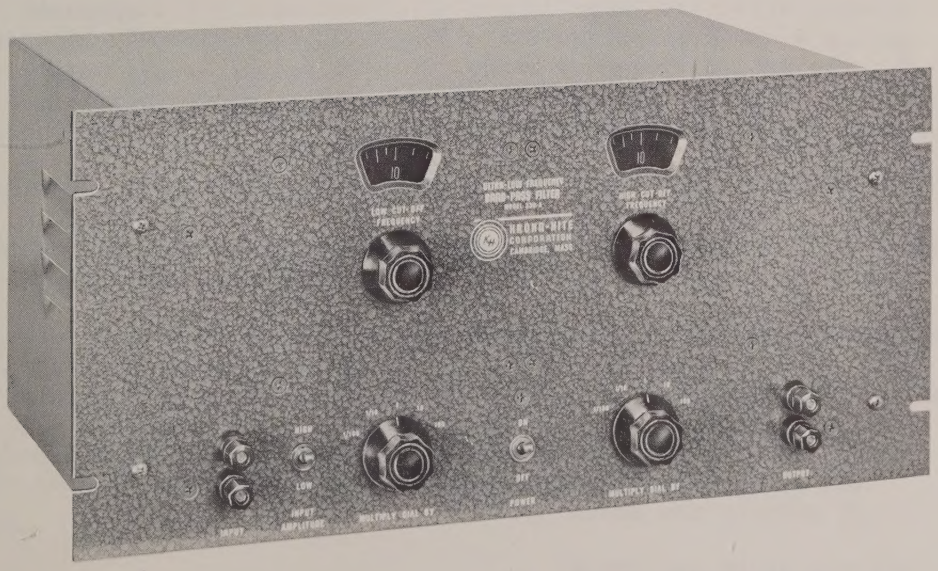


Figure 1 — Ultra-Low Frequency Band-Pass Filters
Models 330-A, 330-M, 330-AR, 330-MR

## SECTION I - GENERAL DESCRIPTION

### 1. TECHNICAL SUMMARY

TYPE: Band-Pass.

BAND WIDTH: Continuously variable up to the maximum width covering the entire range from 0.02 cps to 2 kc in the Model 330-A(R) and from 0.2 cps to 20 kc in the Model 330-M(R).

FREQUENCY RANGE: Continuous coverage over the entire frequency range for both high cut-off and low cut-off frequencies independently; frequency range is covered by separate calibrated dials and five-decade band switches; center frequency and width of pass band continuously adjustable within the designated frequency range.

| | | FREQUENCY (CPS) | |
|---|---|---|---|
| BAND | MULTIPLIER | Model 330-A(R) | Model 330-M(R) |
| 1 | 1/100 | 0.02 - 0.20 | 0.2 - 2.0 |
| 2 | 1/10 | 0.20 - 2.0 | 2.0 - 20 |
| 3 | 1 | 2.0 - 20 | 20 - 200 |
| 4 | 10 | 20 - 200 | 200 - 2,000 |
| 5 | 100 | 200 - 2,000 | 2,000 - 20,000 |

FREQUENCY DIALS: Each dial is engraved, illuminated and individually hand calibrated with a single logarithmic scale reading directly in cycles per second from 1.9 to 21 in the Model 330-A(R) and from 19 to 210 in the Model 330-M(R); dials are 5 inches in diameter with an effective scale length of approximately 9 inches per band giving a total effective scale length of approximately 45 inches for the entire frequency range.

*ACCURACY OF CUT-OFF FREQUENCY CALIBRATION: ±5%.

*INSERTION LOSS: ZERO db ±1 db in pass band.

*ATTENUATION SLOPE: Each side, nominal 24 db per octave with peaking factor to reduce attenuation at the cut-off frequencies.

MAXIMUM ATTENUATION: Greater than 80 db.

INPUT CHARACTERISTICS:

IMPEDANCE: Approximately 22 megohms in parallel with 200 mmfd in the Model 330-A(R); approximately 22 megohms in parallel with 20 mmfd in the Model 330-M(R).

MAXIMUM INPUT AMPLITUDE:
10 volts rms with INPUT AMPLITUDE switch in HIGH position;
1 volt rms with INPUT AMPLITUDE switch in LOW position.

MAXIMUM DC COMPONENT: 400 volts.

1. TECHNICAL SUMMARY (cont'd)

OUTPUT CHARACTERISTICS:

*IMPEDANCE: Approximately 5,000 ohms with INPUT AMPLITUDE switch in HIGH position; 500 ohms with INPUT AMPLITUDE switch in LOW position.

MAXIMUM POWER: 5 volts rms across 5,000 ohms or 5 millwatts in HIGH position of the INPUT AMPLITUDE switch.

*INTERNALLY GENERATED HUM AND NOISE: Less than 1 millivolt with INPUT AMPLITUDE switch in HIGH position; less than 100 microvolts with INPUT AMPLITUDE switch in LOW position.

CONTROLS:

LOW CUT-OFF FREQUENCY dial.
Low cut-off frequency MULTIPLY DIAL BY switch.
HIGH CUT-OFF FREQUENCY dial.
High cut-off frequency MULTIPLY DIAL BY switch.
INPUT AMPLITUDE HIGH-LOW switch.
POWER OFF-ON switch.

TERMINALS: Two multi-purpose binding posts for the INPUT and two for the OUTPUT.

POWER REQUIREMENTS:

105-125 volts, single phase.
50-60 cycles (400 cycle model available on special order).
50 watts.

FUSE PROTECTION: 1 ampere slow-blow.

TUBE COMPLEMENT (furnished with instrument): 8-12AX7, 3-12AU7, 1-12AY7, 1-6AU5-GT, 1-6AX5-GT, 1-0G3/85A2.

FORM: Overall dimensions Model 330-A and Model 330-M: 17" wide, 8" high, 12" deep. Weight: Model 330-A, 37 lbs. net, 42 lbs. shipping; Model 330-M, 29 lbs. net, 34 lbs. shipping. Rack mounting available, overall dimensions Model 330-AR and Model 330-MR: 19" wide, 8 3/4" high, 12" deep. Weight: Model 330-AR, 37 lbs. net, 41 lbs. shipping; Model 330-MR, 30 lbs. net, 34 lbs. shipping.

* Refer to corresponding headings under DETAILED SPECIFICATIONS.

## SECTION II - DETAILED SPECIFICATIONS

### 1. ACCURACY OF CUT-OFF FREQUENCY CALIBRATION.

The high and low cut-off frequencies, as defined below, will be within 5% (±5%) of the corresponding dial reading. KROHN-HITE Electronic Filters are calibrated to conform to each of the following definitions:

(a) Cut-off frequency can be defined as the frequency which is the reciprocal of $2\pi T$ in the filter transfer function. At this frequency the phase shift through either the high pass or the low pass filter section alone is exactly 180 degrees.

(b) Cut-off frequency is also the frequency at which the extension of the straight portion of the filter attenuation slope (24 db per octave) intersects the extension of the pass band gain characteristic. If the attenuation rate should differ from 24 db per octave (see ATTENUATION SLOPE below) this method of determining the cut-off frequency is not valid.

(c) From passive filter terminology the cut-off frequency is the frequency at which the output of the filter is 3 db down from the output at the middle of the pass band.

When checking the cut-off frequency calibration accuracy as defined in (c) above, refer to Figure 3. Cut-off frequency gain is the amount by which the filter output at the cut-off frequency differs from the mid-band or mean frequency output. This gain varies with separation of the cut-off frequencies (see FILTER CHARACTERISTICS) and it is plotted in Figure 3 as a function of the ratio of high to low cut-off frequencies. Cut-off frequency gain approaches minus 3 db for wide separations (curve A of Figure 2) has a maximum of about minus 4.2 db for a factor of four separation (curve C of Figure 2) and goes to zero db when the cut-off frequencies coincide.

### 2. INSERTION LOSS.

The filter output voltage under open circuit conditions will be within 1 db (±1 db) of the input voltage for all frequencies within the pass band. The pass band, for the purpose of specifying insertion loss, is defined as the frequency spectrum from ten times the low cut-off frequency setting to one tenth of the high cut-off frequency setting. To determine the insertion loss (pass band gain) accurately, the high and low cut-off frequencies must be at least a factor of one hundred apart, and the measuring frequency must be the geometric mean of these frequencies. Note that in all cases Figures 2, 3, 4, 5 and 6 show a reference output level. The reference output level can be readily converted to input level once the pass band gain has been determined exactly for a particular instrument.

### 3. ATTENUATION SLOPE.

A typical attenuation curve is shown in Figure 4. At the cut-off frequency the slope is approximately 12 db per octave, and at the

12 db point the slope has essentially reached its nominal value of 24 db per octave. The slope of the straight portion of the curve may be slightly less than 24 db per octave at certain frequencies because of cross-coupling effects, and at the extreme ends of the frequency range this slope may exceed 24 db per octave because of the fall-off in internal amplifier gain which adds to the normal attenuation.

4. OUTPUT IMPEDANCE.

The rated output impedance is the source impedance and is also the minimum load that may be connected to the filter. For this value of load the insertion loss will be approximately 6 db. Lower values of load resistance will not damage the instrument but will increase the distortion. Higher values of external load may be used with no sacrifice in performance and correspondingly lower insertion loss. In the case of these instruments there is no requirement that the load impedance match the output impedance.

5. INTERNALLY GENERATED HUM AND NOISE.

This specification is based on the use of Ballantine Model 310 Voltmeter, or equivalent. This measurement is made with the INPUT terminals connected together by a low impedance shorting jumper, no other external signal connections to the instrument and the voltmeter leads shielded.

6. FILTER CHARACTERISTICS.

Several normalized filter characteristics are shown in Figure 2 for different settings of the cut-off frequencies.

Peaking circuits, which are used to sharpen the corners of the pass band characteristic, introduce gain peaks in the pass band approximately one octave above the low cut-off frequency and one octave below the high cut-off frequency. Curves A and B of Figure 2 show gain peaks of about 0.75 db. When the cut-off frequencies are set approximately two octaves apart (a factor of four), the peaks coincide causing a further increase in the gain peak. Curve C of Figure 2 shows a gain peak of about 1.5 db. The improvement in the filter characteristic effected by the corner peaking circuits is shown by the difference between curves A and B of Figure 4.

The typical pass band characteristic for any cut-off frequencies can be plotted from curve C of Figure 4, since the gain at any frequency is the sum of the gains due to both the high and low cut-off filter sections. For example, consider the case mentioned above of high and low cut-off frequency separation of a factor of four. The high cut-off frequency is represented by 1 on the $f/f_H$

scale, the mean frequency is at 0.5 on this same scale, and the curve shows a gain value of 0.75 db. The low cut-off frequency is represented by 1 on the $f_L/f$ scale, the mean frequency is at 0.5 on this scale and a second gain of 0.75 db is shown. The net gain at the mean frequency is 1.5 db with respect to the normal pass band gain. At the high cut-off frequency there will be a loss of 3 db due to the high cut-off section, represented by 1 on the $f/f_H$ scale, and a gain of 0.3 db from the low cut-off section, shown at 0.25 on the $f_L/f$ scale. Gain at both the high and low cut-off frequencies is minus 2.7 db because the curve is symmetrical about the mean frequency. As many more points as required may be determined in a similar manner.

## 7. MINIMUM PASS BAND.

Minimum pass band width is obtained by setting the high and low cut-off frequencies equal. In this case, the lower 3 db point is at 0.77 times the cut-off frequency; the upper 3 db point is at 1.30 times the cut-off frequency, and the insertion loss is 6 db. See Figure 5. Crossing over the high and low cut-off frequencies increases the pass band width and at the same time increases the insertion loss.

## 8. DISTORTION.

Filter distortion is a function of several variables and is difficult to specify exactly. In general, if the filter is operated within its ratings, distortion products introduced by the filter and not present in the INPUT signal will not exceed 0.5% of the OUTPUT signal. In most cases distortion will be considerably less than 0.5%.

## 9. TRANSIENT RESPONSE.

This term is sometimes used in reference to filters in an attempt to specify performance when impulse voltages are applied to the filter input. Mathematical analysis and laboratory measurements show that for a given input signal (complex wave, square wave, step function, etc.) all filters will produce an output signal which depends only on the transfer function vs. frequency and is not affected in any manner by the electrical composition of the filter (RC,m-derived, etc.). The phase and/or amplitude of the individual input signal frequency components may, however, suffer undue distortion at the output if the filter does not have a smooth transfer characteristic with no pronounced peaks. Distortion of this nature is minimized by the design of KROHN-HITE Filters. These filters represent the optimum practical approach to ideal filter characteristics combined with versatility to give unsurpassed performance.

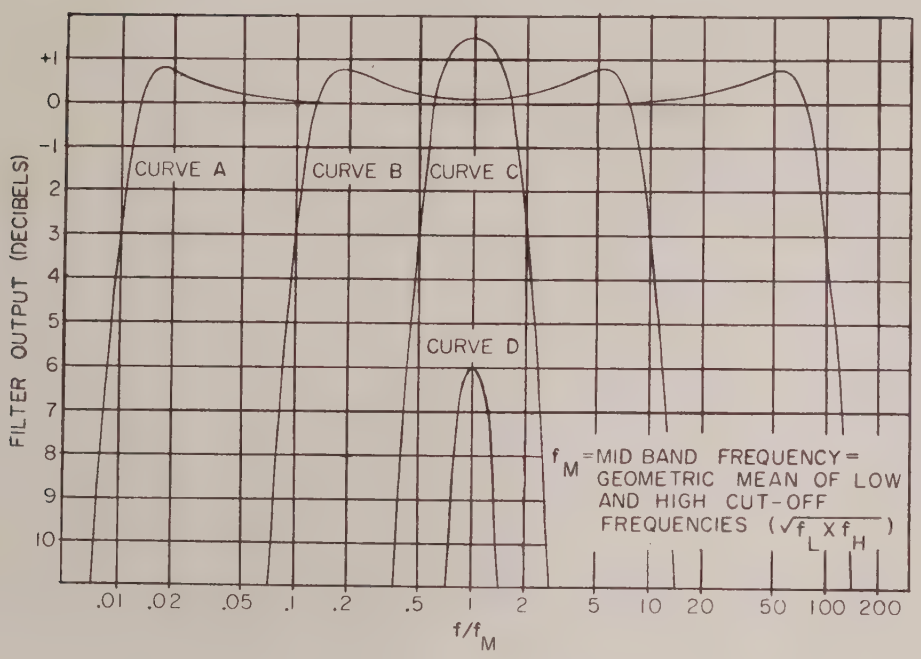



Figure 2 - TYPICAL NORMALIZED PASS BAND CHARACTERISTICS

Curve A

High and low cut-off frequencies separated by a factor of 10,000. Note that the filter gain (insertion loss) through the middle of the pass band is shown as zero db. This is an arbitrary reference level and can vary plus or minus one db from the input signal when there is no load on the filter output.

Curve B

Inter-action of high and low cut-off peaking circuits increases mid-band gain by approximately 0.1 db when the cut-off frequency separation is reduced to a factor of 100.

Curve D

Mid-band gain increased by approximately 1.5 db when high and low cut-off frequency separation is reduced to a factor of 4.

Curve D

Minimum pass band width is obtained by setting the cut-off frequencies equal. Gain at the peak of the pass band is reduced by approximately 6 db. Refer to Figure 5.

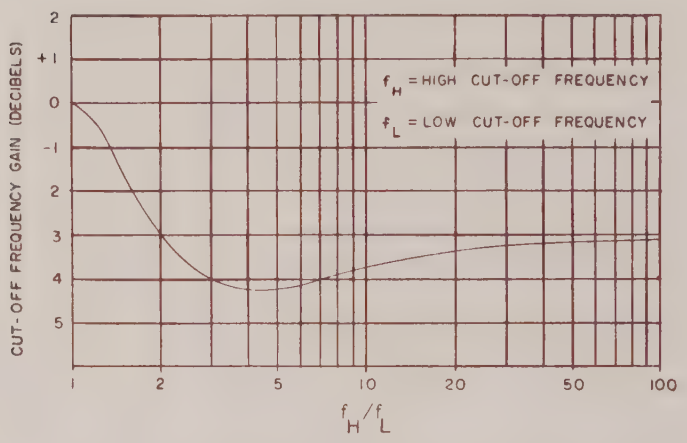



Figure 3 - MODIFIED CUT-OFF FREQUENCY GAIN

Cut-off frequency gain values from this curve must be used in order to check calibration of the filter accurately when high and low cut-off frequency separation is less than a factor of 100. Cut-off frequency gain is the amount by which the filter output at the cut-off frequency differs from the mid-band or mean frequency output. See 1(c) Accuracy of Cut-Off Frequency Calibration.

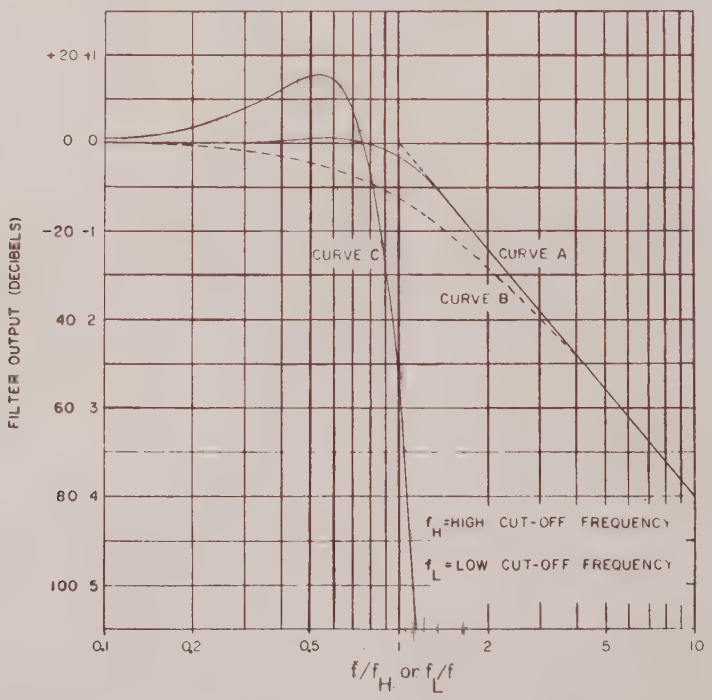
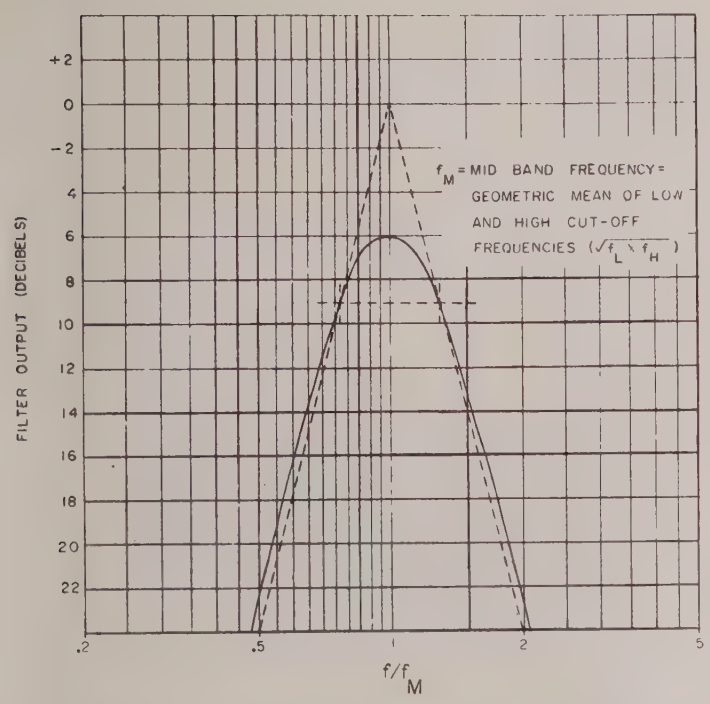



Figure 4 - TYPICAL NORMALIZED ATTENUATION CHARACTERISTICS

Curve A - Attenuation characteristic shown to the minus 80 db level.

Curve B - Attenuation characteristic obtained without corner peaking circuits.

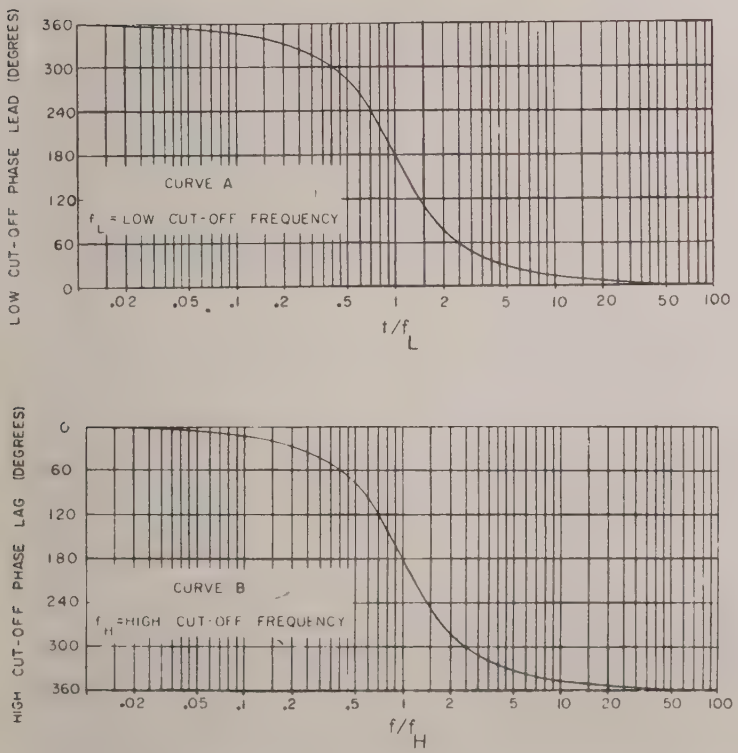
Curve C - Pass Band characteristic near the cut-off frequency (unity) shown on expanded db scale.




Filter pass band characteristic for minimum band-width setting. High and low cut-off frequencies are equal (unity) and insertion loss at the peak of the pass band is 6 db. The 3 db down points, measured from the peak, occur at 0.77 and 1.30 times the cut-off frequency.

Dash lines are extensions of the 24 db per octave slope which intersect the output signal reference level at the cut-off frequency.

Figure 5 - TYPICAL NORMALIZED PASS BAND CHARACTERISTIC - NARROW BAND OPERATION




Phase shift introduced by the low and high cut-off filter sections is shown by Curves A and B respectively where the cut-off frequencies are represented by unity on the normalized frequency scale. Total phase shift through the filter at any frequency is the sum of the phase shifts of the low and high cut-off sections at that frequency. Phase lag is considered to have a negative sign and phase lead a positive sign.

Figure 6 - TYPICAL NORMALIZED PHASE CHARACTERISTICS

## SECTION III - DESCRIPTION

The Models 330-A(R) and 330-M(R) ULTRA-LOW FREQUENCY BAND-PASS FILTERS, shown in Figure 1, are adjustable filters whose gain is unity in the pass band and drops outside the pass band at a rate of 24 db per octave. The instruments are completely electronic and easily portable. They operate from an ac source of 105-125 volts, 50-60 cycles per second. An integral power supply furnishes the heater voltages and the regulated dc voltages required for operation. The Models 330-AR and 330-MR are rack mounted units of the Models 330-A and 330-M.

Both the high and low cut-off frequencies are independently adjustable from 0.02 cps to 2 kc in the 330-A(R) and from 0.2 cps to 20 kc in the 330-M(R). This provides maximum flexibility of adjustment of both the band center frequency and the band width. Two identical frequency dials and multiplier switches are used for the cut-off frequencies. Each dial is single scale, illuminated, direct reading, and engraved logarithmically from 1.9 to 21 in the 330-A(R) and from 19 to 210 in the 330-M(R). The associated multiplier switch selects one of the five decade bands. The transfer function of the filter is approximately:

$$\frac{\omega^4 T_1^4}{[(1+2jA\omega T_1-\omega^2 T_1^2)^2]\ [(1+2jA\omega T_2-\omega^2 T_2^2)^2]}$$

where the low cut-off frequency is $1/2\pi T_1$ and the high cut-off frequency is $1/2\pi T_2$. The value of the peaking factor, "A", which is normally unity for filters composed of independent resistance-capacitance sections, is fixed in the Models 330-A(R) and 330-M(R) at approximately 0.6. This value produces less than 1 db peaks in the gain versus frequency plot, but reduces the attenuation at the corner frequencies by approximately 9 db, and permits a band width as narrow as one octave with very little attenuation in the center of the pass band.

Figure 11 shows the essential units of the filter in block diagram form. For more details refer to Schematic Diagram, Figure 15.

The filter section combines a high pass filter and a low pass filter. Each is tuned continuously by a four gang potentiometer assembly and in decade steps by a multiplier switch, which changes the size of the filter capacitors.

The input amplifier serves as a buffer between the input and the first filter. Sufficient amplification is used to overcome the loss in the filters so that the overall attenuation from input to output is approximately zero db in the pass band.

Since capacitance coupling is used at the input to this amplifier, a dc signal component will not disturb the operation of the filter. The output circuit is used as a buffer to isolate the last filter and to provide a low output impedance.

## SECTION IV - INSTALLATION AND OPERATION

The Models 330-A(R) and 330-M(R) ULTRA-LOW FREQUENCY BAND-PASS FILTERS are completely checked and then carefully packed for shipment to insure you of an instrument that is ready for operation. The filter is easy to operate and requires no initial warm-up period or adjustment.

There are only five front panel controls in addition to the OFF-ON switch.

The HIGH CUT-OFF FREQUENCY and LOW CUT-OFF FREQUENCY controls select the cut-off frequencies as read on single scale illuminated dials, which are engraved logarithmically and calibrated directly in cycles per second.

The two MULTIPLY DIAL BY switches select the proper multiplying factor for all the five bands, each of which covers a frequency range of 10 to 1 with 5% overlap.

The INPUT AMPLITUDE switch permits selection of filter characteristics which are most suitable for a particular application. In the HIGH position the filter will handle an input signal of at least 10 volts rms without overloading. The output impedance is 5,000 ohms and noise generated within the filter is less than one millivolt. For input signals less than one volt rms, the LOW position of the amplitude switch may be used to obtain 500 ohms output impedance and noise reduction by a factor of 10. Gain in the pass band is unity for both positions of the amplitude switch.

The basic circuit of one of the high cut-off sections of the filter is shown in Figure 7.

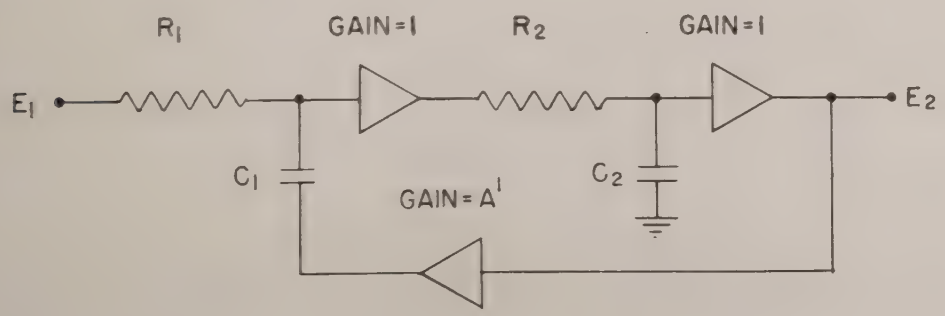



Figure 7 - FUNDAMENTAL CIRCUIT OF ONE HIGH CUT-OFF SECTION

This basic circuit consists of two high cut-off RC sections coupled by unity gain buffer amplifiers. A feedback signal of $A^1E_2$ is fed back to the first capacitor. If both capacitors are the same, this circuit has a transfer characteristic of:

$$\frac{E_2}{E_1} = \frac{1}{j^2\omega^2 (R_1C\ R_2C) + j\omega\ [R_2C + (1-A^1)R_1C] + 1}$$

At the cut-off frequency where

$$j^2\omega^2 R_1C\ R_2C + 1 = 0 \text{ and } \omega_{co} = 1/\sqrt{R_1CR_2C}$$

The gain of the circuit is:

$$G_{co} = \frac{1}{\sqrt{R_2/R_1} + (1-A^1)\sqrt{R_1/R_2}}$$

Thus the $G_{co}$ can be controlled by adjusting "$A^1$" and the ratio $R_2/R_1$. The peaking of the response curve for three different values of $G_{co}$ is shown in Figure 8.

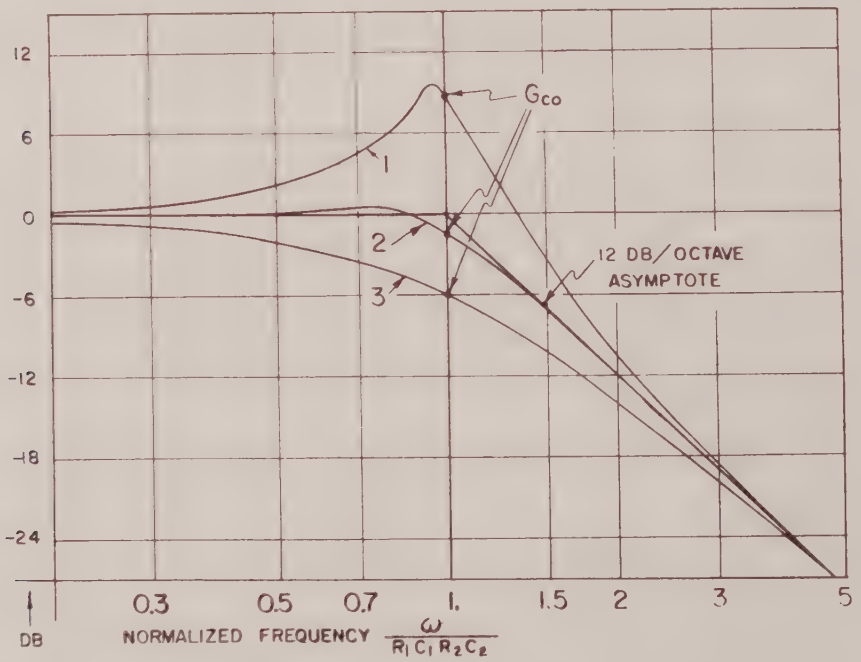



Figure 8 - EFFECT ON CORNER PEAKING CAUSED BY CHANGING $G_{co}$

Curve 2 is the one used in the filter and is achieved by setting $A^1 = 0.8$ and $R_2/R_1 = 1$ giving a $G_{co}$ for one 12 db per octave section of approximately -.5 db.

The basic circuit of one of the low cut-off sections of the filter is shown in Figure 9.

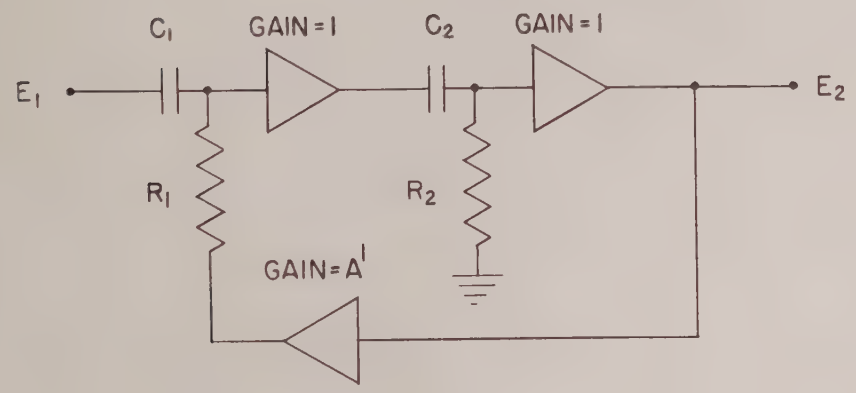



Figure 9 - FUNDAMENTAL CIRCUIT OF ONE LOW CUT-OFF SECTION

The equations for this circuit are:

$$\frac{E_2}{E_1} = \frac{j^2\omega^2 R_1C\ R_2C}{j^2\omega^2 R_1C\ R_2C + j\omega\ [R_1C = (1-A')R_2C] + 1}$$

$$\omega_{co} = 1/\sqrt{R_1C\ R_2C}$$

$$G_{co} = \frac{1}{\sqrt{R_1R_2} + (1-A')\sqrt{R_2/R_1}}$$

The response curves for this circuit come out symmetrical with those on Figure 8 about the $\omega = 1.0$ axis. Again, curve 2 is the one used in the filter and is achieved by setting $A^1 = 0.8$ and $R_1/R_2 = 1$.

The whole filter consists of two high cut-off sections and two low cut-off sections, giving a total peak of about 0.75 db, a total $G_{co}$ of -3 db and a total slope of 24 db per octave at both ends of the pass band. This choice of peaking results in only a small (0.75 db) peak in the curve, but reduces the corner frequency attenuation by 9 db from that obtained by four independent RC sections.

For most applications, the Model 330-A(R) or 330-M(R) is superior to a 24 db filter with independent RC sections, because with the same attenuation outside the pass band, the gain near the corner frequencies is greater. Figure 10 shows the response of these filters (solid curve) and of a similar filter with independent RC sections (dotted curve). The low cut-off frequency is 40 cps, and the high cut-off frequency is 160 cps.

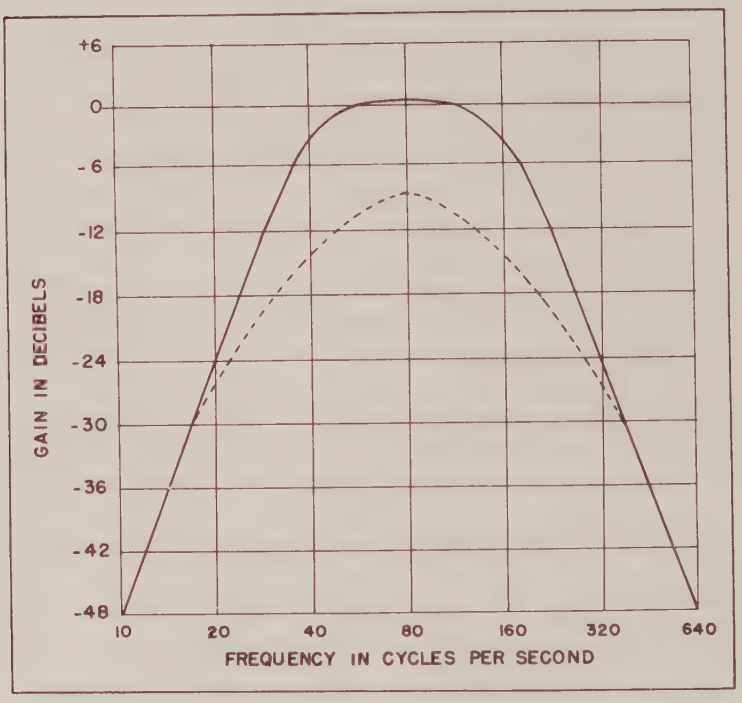



Figure 10 - Solid curve shows the Band-Pass response of the Models 330-A(R) and 330-M(R). Dotted curve is the response of a similar filter with independent RC sections.

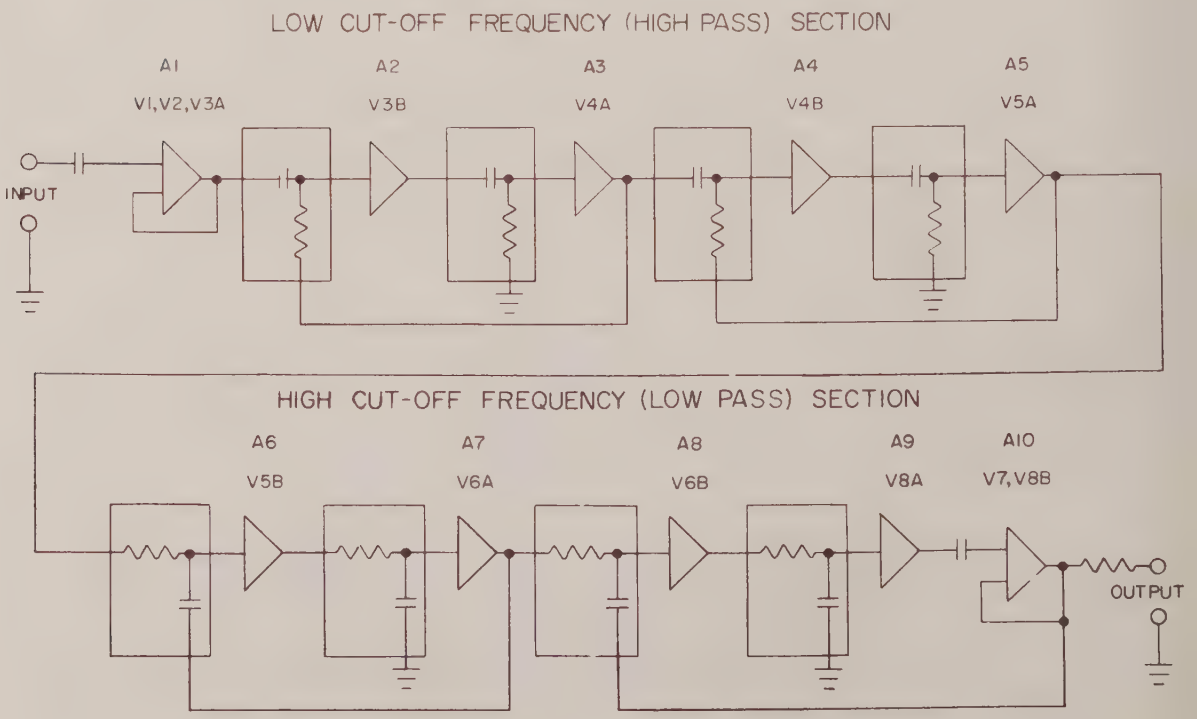



Figure 11 - BLOCK DIAGRAM Models 330-A(R) and 330-M(R)

## SECTION V - MAINTENANCE

All the components in the Models 330-A(R) and 330-M(R) are of the highest quality and should have a long trouble-free life since they are operated well below their manufacturer's rating. The following procedure may facilitate locating the source of trouble if the filter does not function properly.

A 1-Ampere (slow-blow) cartridge fuse, located on the rear of the chassis, is used in the primary circuit of the power transformer to protect the power supply components from short circuits. The rating of this fuse was selected for proper protection of the instrument and should be replaced with the same type and rating.

If a fuse failure is detected the following procedure is recommended before replacing the fuse.

(a) Check for a faulty rectifier tube, 6AX5-GT.

(b) Short circuits in 4MFD filter condensers, C54 and C55 used in the unregulated portion of the power supply, can best be detected by connecting an ohmmeter across the terminals directly.

(c) Two electronically regulated power supplies are used in the Models 330-A(R) and 330-M(R) to provide +185 volts and -185 volts with respect to the chassis or ground. One convenient test point for the +185 volts is the cathode of the 6AU5-GT (pin 3). A convenient test point for -185 volts is the negative side of the 4MFD filter condensers, C54 and C55. If a short to ground exists on either regulated voltage buss, check all the tie points connected to it.

(d) The dc resistance of the Power Transformer primary should be 4.5 ohms. A much lower resistance probably indicates a shorted primary.

The likeliest source of failure is the electron tubes since they have an inherently shorter life. Check first to see if all the tubes are inserted securely in the sockets. Although all tubes are securely seated at the plant, it is possible for them to be loosened in shipment. At the same time note if each tube's filament is lit and the voltage reference tube OG3/85A2 is functioning properly as indicated by an amber glow in the tube. If the unit then fails to operate properly and the correct plate and heater supply voltages are present, check the possibility of a faulty tube. Obtain a new 12AU7, 12AX7 and 12AY7 (a 12AX7 may be substituted for a 12AY7 for this test), and then one at a time, substitute the new tube in each position in the filter where it is used. The location of each electron tube is clearly marked on the chassis adjacent to the tube.

In most cases, one of these substitutions will affect a cure. If, however, this approach does not help, a detailed point to point signal tracing analysis should be made.

Apply a 200 cps 10 volt rms sine wave to the INPUT of the filter with the INPUT AMPLITUDE switch in the HIGH position. Set the LOW CUT-OFF FREQUENCY dial to 20 cps and the HIGH CUT-OFF FREQUENCY dial to 2,000 cps. When the filter is operating properly this 200 cps test signal will pass through the filter unchanged and appear on the output with equal amplitude. If the test signal does not appear on the output of the filter it is advisable, at first, to localize the malfunction by determining where the test signal fails to appear within the filter.

Test points in the filter with their correct signal voltages are listed below, in Figure 12, for a 10 volt rms sine wave input. If the test point voltage differs appreciably from the correct voltage, all of the components, wiring, and voltage and resistance readings to ground associated with the tube(s) preceeding the test point should be checked.

LOW CUT-OFF AT 20 CPS - HIGH CUT-OFF AT 2 KC
INPUT AMPLITUDE SWITCH IN "HIGH" POSITION
200 CPS, 10 VOLTS RMS INPUT

| TEST POINT | | CORRECT SIGNAL VOLTAGE | |
|---|---|---|---|
| TUBE No. | PIN No. | 330-A(R) | 330-M(R) |
| V3 | 8 | 16.5V | 30.5V |
| V3 | 3 | 15.6V | 11.5V |
| V4 | 8 | 15.1V | 11.3V |
| V4 | 3 | 15.1V | 11.1V |
| V5 | 3 | 14.6V | 10.9V |
| V5 | 8 | 14.5V | 10.8V |
| V6 | 3 | 11.6V | 8.4V |
| V6 | 8 | 11.5V | 8.3V |
| V8 | 3 | 9.2V | 6.7V |
| V7 | 2 | 9.2V | 6.7V |
| V8 | 8 | 10V | 10V |

Figure 12 - TEST POINT VOLTAGES

The range (band) switching capacitors associated with S1 and S2 are specially selected for capacity tolerance. All capacitor values are within ±5% of the specified value, but in order to maintain accurate calibration on all bands, the capacitors on each switch section are so selected that their values are a factor of ten apart within ±2%. The tolerance of all frequency determining capacitors in any one instrument will therefore lie within 2% of the tolerance value rubber-stamped on the 1 UF (200V) capacitors. The dial engraving of the variable resistance elements P1 and P2 is altered to match the overall capacitance tolerance used in each instrument.

Referring to the Schematic Diagram, Figure 15, variable resistances P1-A, B, C and D and P2-A, B, C and D are ganged together and comprise the filter tuning elements. Because high values of resistance which are not obtainable in wire-wound units are required for very low frequency operation, these resistance elements are composition potentiometers, carefully selected, aged, phased and individually hand calibrated in assemblies of four potentiometers each to ensure accurate overall calibration and good tracking over the entire dial. Since these potentiometers are not subjected to appreciable voltages, the only cause of any difficulty should normally be mechanical wear. Our experience with these units over a period of years confirms our original conclusion that, except in rare cases, the potentiometers will have a life equal to or exceeding the normal instrument life.

Should it be necessary for any reason to replace one or more of these potentiometers we strongly recommend that the entire assembly of four potentiometers be replaced with an assembly supplied by the factory complete with its individually calibrated dial.

In an emergency, one potentiometer can be replaced in an assembly and aligned at one point, 6 on the 330-A(R) dial and 60 on the 330-M(R) dial, for example. However, because of differences in potentiometer resistance vs. rotation characteristics, other points on the dial may be in error. The net instrument calibration error will be approximately one-quarter of the potentiometer tracking error at any given point on the dial.

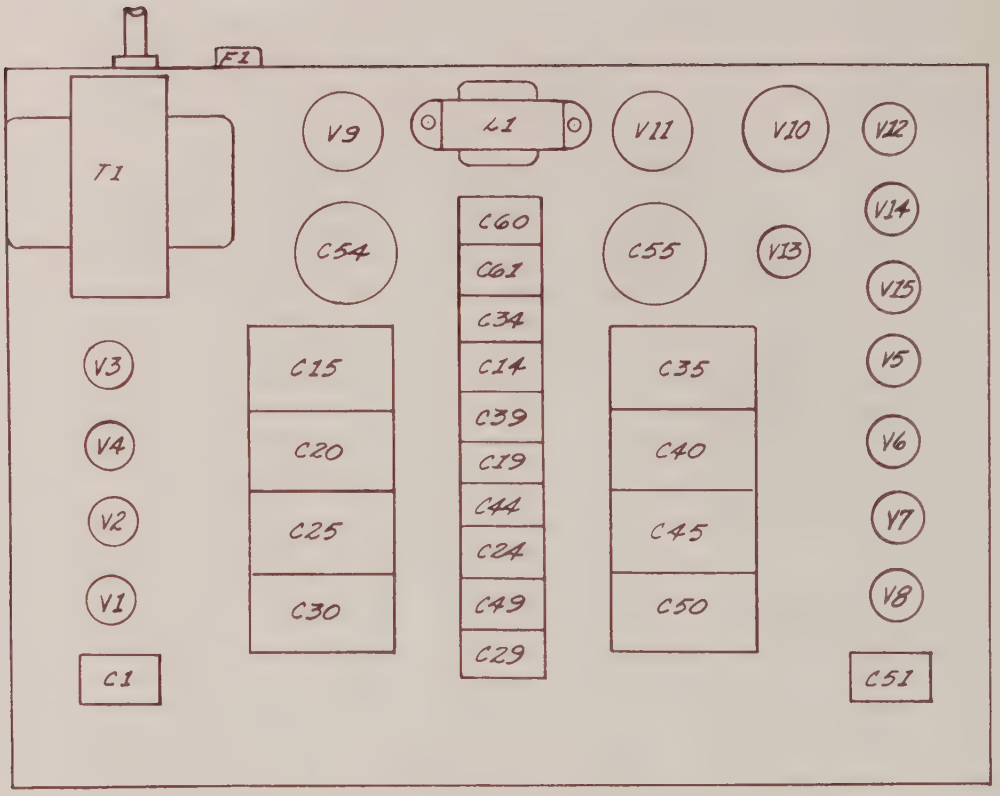



Figure 13 - Model 330-A(R) TOP VIEW OF CHASSIS

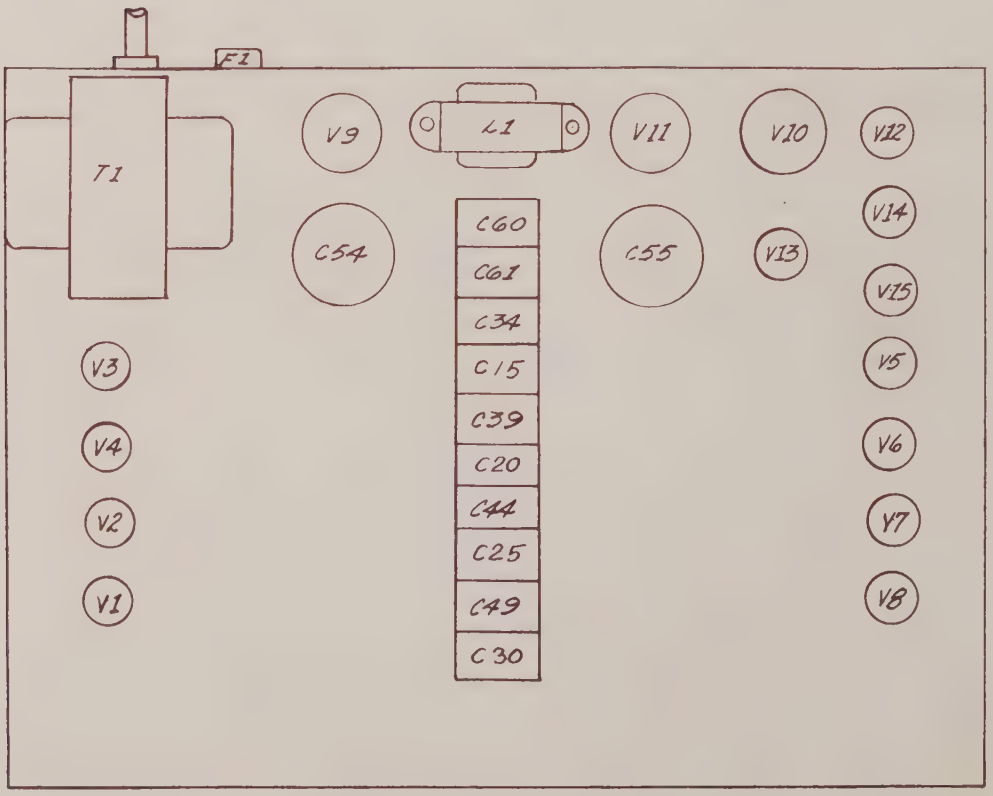
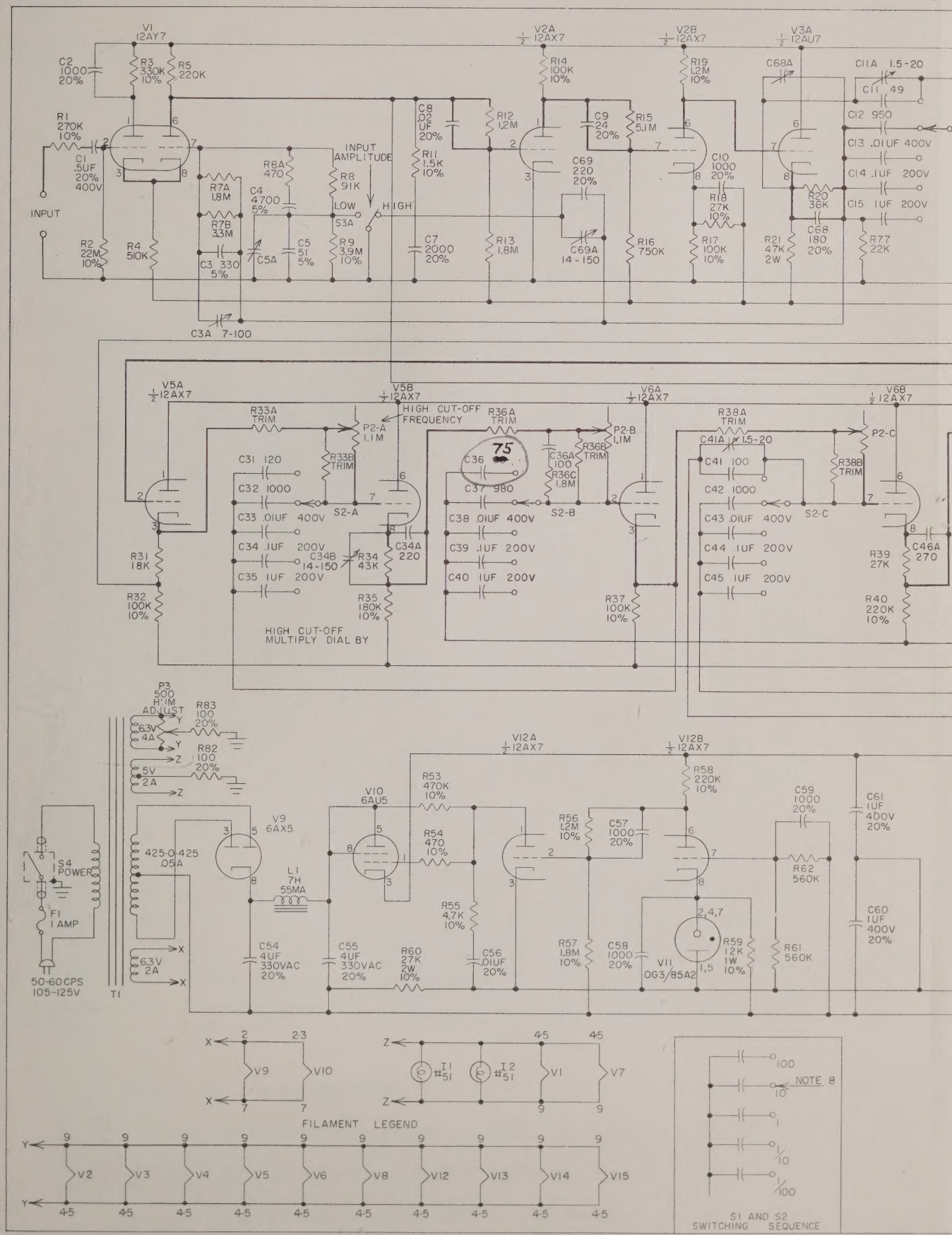
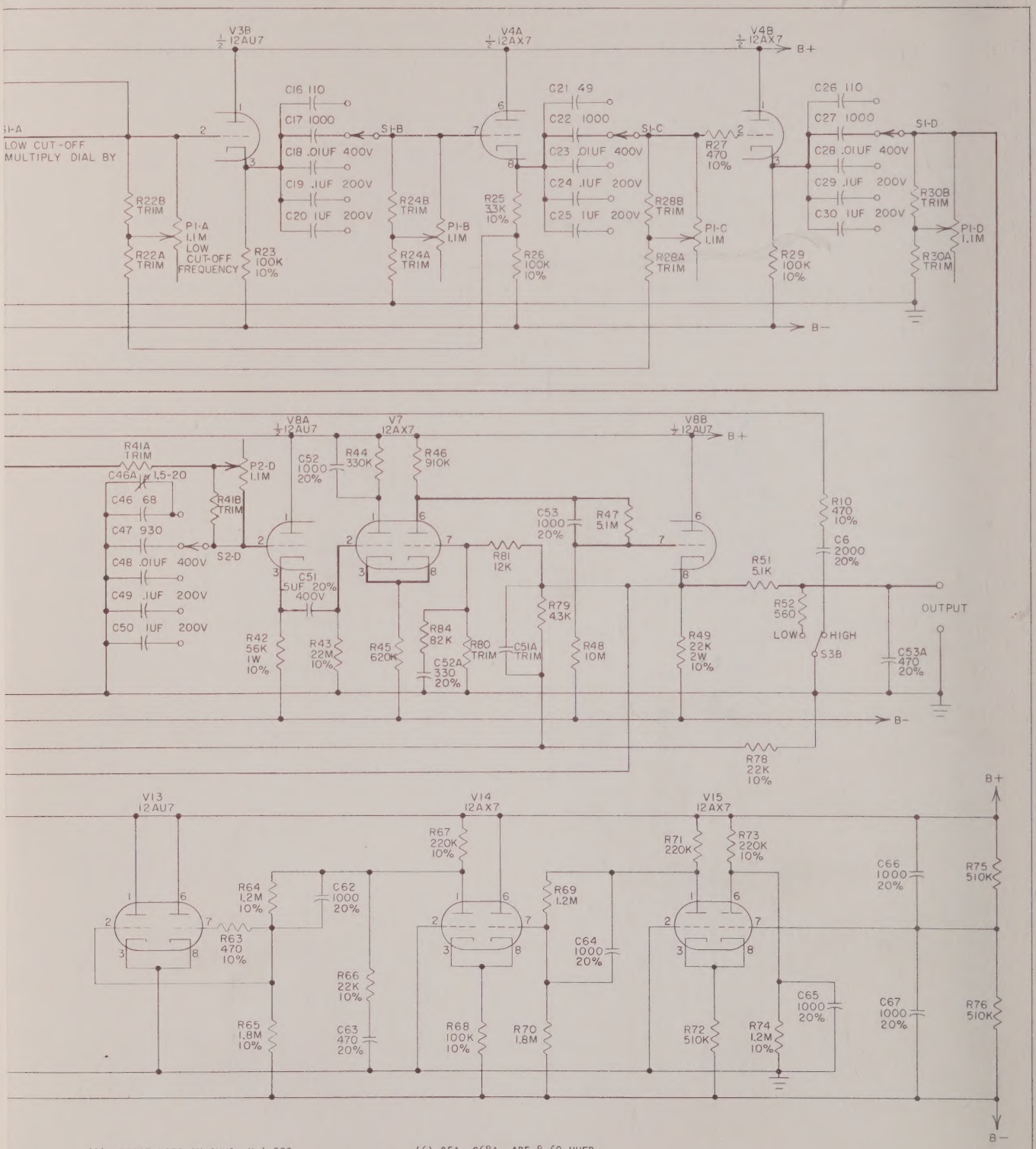



Figure 14 - Model 330-M(R) TOP VIEW OF CHASSIS


V1 12AY7
V2A ½ 12AX7
V2B ½ 12AX7
V3A ½ 12AU7
INPUT
INPUT AMPLITUDE
LOW
HIGH
S3A
C3A 7-100
V5A ½ 12AX7
V5B ½ 12AX7
V6A ½ 12AX7
V6B ½ 12AX7
HIGH CUT-OFF FREQUENCY
S2-A
S2-B
S2-C
HIGH CUT-OFF MULTIPLY DIAL BY
V12A ½ 12AX7
V12B ½ 12AX7
V10 6AU5
V9 6AX5
V11 OG3/85A2
P3 500 H'IM ADJUST
6.3V 4A
5V 2A
425-0-425 .05A
6.3V 2A
S4 POWER
F1 1 AMP
50-60CPS 105-125V
T1
L1 7H 55MA
FILAMENT LEGEND
NOTE 8
S1 AND S2 SWITCHING SEQUENCE




(1) RESISTANCES IN OHMS K=1,000 M=MEG=1,000,000.

(2) RESISTORS ±5% 1/2 WATT UNLESS OTHERWISE SPECIFIED.

(3) CAPACITANCES IN UUF UNLESS OTHERWISE SPECIFIED.

(4) CAPACITORS ±10% 500WVDC UNLESS OTHERWISE SPECIFIED.

(5) ALL COMPONENTS LABELLED TRIM ARE FACTORY ADJUSTMENTS.

(6) C5A, C68A, ARE 8-60 UUFD TRIMMER CONDENSERS.

(7) S1 AND S2 SHOWN IN THE X10 POSITION.

(8) ALL CAPACITORS SWITCHED BY S-1 AND S-2 HAVE A BASIC TOLERANCE OF ±5% OF THE VALUE SHOWN. IN ANY ONE INSTRUMENT THESE CAPACITORS ARE SELECTED TO FALL IN DECADE STEPS WITHIN 2%, EXCEPT ON THE HIGHEST FREQUENCY BANDS WHICH ARE COMPENSATED FOR STRAY CAPACITANCES.

ULTRA-LOW FREQUENCY BAND-PASS FILTER

| SCALE | FIGURE - 15 | DRAWN BY AHW |
|---|---|---|
| DATE 8-13-58 | | REVISED 9-10-59 |

SCHEMATIC DIAGRAM MODEL 330-M(R)

KROHN-HITE CORPORATION
CAMBRIDGE, MASSACHUSETTS

DRAWING NUMBER C-330M-1

**KROHN-HITE CORPORATION**

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